Department of Defense
Investigation of the Feasibility of Accommodating the International Mobile Telecommunications (IMT) 2000 Within the 1755-1850 MHz Band

9 February 2001

EXECUTIVE SUMMARY

In October 2000, President Clinton initiated an interagency process to consider the feasibility of accommodating International Mobile Telecommunications for the Year 2000 (IMT-2000) within the 1755-1850 and 2500-2690 MHz radio frequency bands. The following report documents the Defense Department's regulatory, technical, operational, and cost assessment with respect to the feasibility of accommodating IMT-2000 systems in the 1755-1850 MHz band.

The conclusions of this report are based on the fundamental principle that the Department of Defense (DoD) cannot accept any degradation to mission capability resulting from a spectrum reallocation action. Loss of access to spectrum, above and beyond that already relinquished as a result of the Omnibus Budget Reconciliation Act of 1993 and the Balanced Budget Act of 1997, would jeopardize the DoD's ability to execute its mission. Congress, recognizing this principle in the National Defense Authorization Act (NDAA) for Fiscal Year 2000, has directed that the Defense Department shall not surrender use of a band of frequencies in which it is a primary user, as is the case with regard to the 1755-1850 band, unless an alternative band or bands are provided of comparable technical characteristics that will ensure no loss of mission capability (as certified by the Secretary of Defense, Chairman of the Joint Chiefs of Staff, and the Secretary of Commerce). Hence, any reallocation action would have to meet the following specific conditions:

1. If a decision is made to vacate all or a part of the 1755-1850 MHz band, the DoD must retain protected access until the last DoD system has migrated. Current regulatory provisions that protect existing DoD operations in the band must continue throughout any migration or transition period.
2. DoD must be provided regulatory protection in any new band associated with a reallocation action equivalent to the protection currently provided in the 1755-1850 MHz band.
3. DoD systems moving to a new band must receive timely domestic spectrum certification and have reasonable prospect of achieving international coordination consistent with mission requirements.
4. During any transition period in which DoD is moving out of the band or a portion thereof, new users would be allowed to operate in the band only to the extent that their operations do not interfere with DoD operations.
5. Timely cost reimbursement must be provided to the DoD per NDAA 1999.

The wide variety of systems the DoD operates in the 1755-1850 MHz band are unique to this band and crucial to the defense of the United States (US) and its allies. The 1755-1850 MHz band is used for critical national defense systems such as telemetry, tracking, and commanding of satellite systems (i.e., Global Positioning System (GPS), Milstar, and Defense Support Program (DSP), among others); precision guided munitions; tactical radio relay communication systems; air combat training systems; targeting; intelligence; and the real-time delivery of voice, video, and data information to warfighters and their commanders. The US and its national defense forces would be at a substantial strategic and tactical disadvantage in combat and the outcome of battles and peacekeeping operations could be jeopardized if the DoD were to lose its use of the band without provision of comparable spectrum and satisfaction of other conditions as presented in Section 2, *Essential Conditions*.

This report examines the feasibility of accommodating IMT-2000 systems by sharing the 1755-1850 MHz band with the DoD. Full band sharing was examined. Predicted interference to both IMT-2000 and DoD systems would preclude compatible operation at a large number of metropolitan areas and over large geographic areas of the country. Unacceptable operational restrictions would be required to mitigate the interference with IMT-2000 systems. *Therefore, full band sharing is not possible.*

This report also examines whether the DoD can fully vacate the 1755-1850 MHz band to accommodate IMT-2000. The most optimistic estimates, based on funding being available in Fiscal Year 2002 (FY02) to accomplish programmatic actions, indicate the *DoD is unable to totally vacate this band until well beyond the timelines established for this study (i.e., by 2003, 2006, or 2010). Estimates indicate that, regardless of financial investment, vacating the band could not be accomplished for most non-space systems until 2010 and beyond; and legacy space systems would require continued protected access to this spectrum until 2017 and beyond.* The preliminary estimated cost to transition DoD systems out of the band in accordance with these acceptable DoD timelines, is in excess of $4.3B in Then Year dollars (TY$). Migration prior to these dates would require premature system termination, which would have extremely serious implications to the DoD's ability to effectively execute its mission. Total relocation from the band is impossible unless comparable spectrum that is operationally suitable with equivalent regulatory protection is made available and the costs of relocation are fully reimbursed. This report, however, indicates operationally suitable comparable spectrum may not be readily available.

Band segmentation options consistent with the options presented in the US Study Plan are also assessed. The segmentation options are:

- Band segmentation/Partial Band Sharing
  - 1755-1805 MHz retained for operation of government systems and 1805-1850 MHz potentially reallocated to non-government use
  - 1790-1850 MHz retained for operation of government systems, and 1755-1790 MHz potentially reallocated to non-government use as part of a phased sharing approach (1710-1755 MHz available immediately, 1755-1780 MHz available at some mid-term future date, and 1780-1790 MHz would be made available in the long term).
- Band segmentation/Partial Band sharing (as above) with the addition of access to Alternate (comparable) Bands

Due to the potential for degradation to operational capability, losing access to any portion of the 1755-1850 MHz band without access to additional comparable spectrum and adequate time to withdraw from the specified band is unacceptable to the DoD. If the conditions of provision of comparable spectrum, full cost reimbursement, on time program execution, and operationally protected use of the spectrum through the course of any necessary transition are met, some band segmentation may be feasible. The feasibility of any segmentation requires the full cooperation of, among other things, the Federal Communications Commission, the National Telecommunications and Information Administration, the IMT-2000 Industry, and other users of the radio spectrum. This cooperation entails acceptance of DoD transition timelines and DoD's continued unrestricted operation in the existing band during the course of any transition. *The timelines for accommodation of IMT-2000 in any segment of the 1755-1850 MHz band by the DoD are comparable to those of full band sharing.* Even if the above conditions are met, transition by the DoD for this option could not be completed until 2010 and beyond for most non-space systems and until 2017 and beyond for the space systems. The preliminary estimated cost to relocate DoD systems in accordance with these acceptable DoD timelines, for the band segmentation options range from at least $2.8B (TY$) to in excess of $4.3B (TY$). As in the case of vacating the total band, migration prior to these dates would require premature system termination, which would have extremely serious implications to the DoD's ability to effectively execute its mission. These dates are also predicated on funding availability in FY02.

The following bands were assessed for their ability to accommodate additional DoD systems migrated from the 1755-1850 band due to IMT-2000 accommodation: 2025-2110 MHz; 2200-2290 MHz; 4.4-5.0 GHz; and 7-8 GHz. Preliminary review indicates these bands could not accommodate the introduction of the additional non-space systems without operational degradation to and from critical systems such as the Cooperative Engagement Capability, the Defense Satellite Communication System,

DoD satellite downlinks, and numerous fixed and mobile operations. The 2025-2110 MHz band may be feasible for the introduction of the DoD satellite operations functions but there are specific regulatory issues that must be addressed. Although other bands were not evaluated in this report, the availability of sufficient comparable spectrum is suspect in light of the ever-growing demand and competition for spectrum access.

In assessing the feasibility of sharing or segmentation of the designated band, or migration out of the band, this report addressed only existing and planned DoD systems. Given the growing demand for spectrum to support information-intensive operations, it is highly likely that new DoD requirements for this band and other DoD bands will arise. Thus the full impact to DoD of surrendering all or a portion of the band is likely to be greater than the assessment provided in this report.

The findings in this report are the result of a very compressed schedule, initiated by the 13 October 2000 Presidential Memorandum (PM) and the related 20 October Commerce Department Plan to Select Spectrum for third-generation (3G) Wireless Systems in the Unites States, that did not provide time for thorough analysis and review of the complex subject. Additional analysis may be required in some areas. The results of this expedited study are especially sensitive to the assumptions used in the assessment. Some of the more critical assumptions include: the relocation band selected for systems that must move; no satellites will require replacement prior to programmed replenishment; and IMT-2000 parameters. If these, or any other of the assumptions used in this assessment are altered, the results presented will significantly differ and require reassessment. Furthermore, the timelines assumed programming, budgeting, and contracting processes are successfully executed without schedule perturbations. Finally, the costs estimated herein do not take into consideration the potential secondary and tertiary costs of moving incumbent DoD users out of the band, with attendant operational changes in tactics, training, doctrine, personnel, and long-lead procurement.

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GLOSSARY

3G	Third-Generation
A/A	Air-to-Air
A/G	Air-to-Ground
AAPG	Aircraft Inter-Antenna Propagation with Graphics
AAU	Alaska Upgrade
AAW	Anti-Air Warfare
ACC	Air Combat Command
ACE	Army Corps of Engineers
ACMI	Air Combat Maneuvering Instrumentation
ACTS	Air Combat Training System
ACUS	Army Common User System
ADT	Applied Data Technology
AEHF	Advanced Extremely High Frequency
AFB	Air Force Base
AFFMA	Air Force Frequency Management Agency
AFS	Air Force Station
AFSATCOM	Air Force Satellite Communications System
AFSCN	Air Force Satellite Control Network
AFSPC	Air Force Space Command
AFWTF	Atlantic Fleet Warfare Training Facility
AGM-130	Air-to-Ground Missile 130
AIS	Airborne (or Aircraft) Instrumentation Subsystem
AISI	Airborne (or Aircraft) Instrumentation Subsystem Internal
AISI(K)	Airborne (or Aircraft) Instrumentation Subsystem Internal Encrypted
AM	Amplitude Modulated
AMRAAM	Advanced Medium Range Air-to-Air Missile
ANGB	Air National Guard Base
ARSR	Air Route Surveillance Radar
ARTS	Automated Remote Tracking Stations
ATC	Aberdeen Test Center
ATM	Aeronautical Telemetry
AW/NTC-IS	Air Warrior/National Training Center Integration System
AWACS	Airborne Warning and Control System
BAS	Broadcast Auxiliary Service
BBA-97	Balanced Budget Act of 1997
BER	Bit Error Rate
BG	Battlegroup
BPSK	Binary Phase Shift Keying
BRH	Beyond Radio Horizon

C/NOFS	Communications/Navigation Outage Forecast System
C2	Command and Control
C3	Command, Control, and Communications
CAIG	Cost Analysis Improvement Group
CATF	Commander Amphibious Task Force
CBRNE	Chemical, Biological, Radiological, Nuclear and High Yield Explosives
CDMA	Code Division Multiple Access
CEC	Cooperative Engagement Capability
CEP	Cooperative Engagement Processor
CFR	Code of Federal Regulations
CIDDS	Combat Identification for the Dismounted Soldier
CJTF	Commander Joint Task Force
CLF	Commander Landing Force
Combat ID	Combat Identification
COMSEC	Communication Security
CONUS	Continental United States
COTS	Commercial-off-the-Shelf
CSEL	Combat Survivor/Evader Locator
CTS	Colorado Tracking Station
CU	Cooperating Unit
CWCS	Countermeasures Warning and Control System
DAMA	Demand Assigned Multiple Access
dB	Decibel
dBHz	Decibel Hertz
dBi	Decibel Above Isotropic
dBm	Decibel Above a Milliwat
dBW	Decibel Above a Watt
dBW	Decibel Above a Watt per Hertz
DDS	Data Distribution System
deg	Degree
DISN	Defense Information Services Network
DLT	Data Link Terminal
DME	Distance Measuring Equipment
DMSP	Defense Meteorological Satellite Program
DoC	Department of Commerce
DoD	Department of Defense
DoE	Department of Energy
DQPSK	Differential Quadrature Phase Shift Keying
DRRTS	Dynamically Reconfigured Real Time Software
DS	Direct Sequence
DSCS	Defense Satellite Communications System
DSN	Deep Space Network
DSP	Defense Support Program
DTED	Digitized Terrain Elevation Data

DWTS	Digital Wideband Transmission System
E&MD	Engineering and Manufacturing Development
EAC	Echelons Above Corps
ECAC	Electromagnetic Compatibility Analysis Center
ECB	Echelons Corps and Below
EDGE	Enhanced Data Rates for GSM Evolution
EES	Earth Exploration Satellite
EHF	Extremely High Frequency
EIRP	Effective Isotropic Radiated Power
EMC	Electromagnetic Compatibility
EME	Electromagnetic Environment
EMI	Electromagnetic Interference
ENG	Electronic News Gathering
EVCF	Eastern Vehicle Checkout Facility
EW	Electronic Warfare
FAA	Federal Aviation Administration
FARP	Fighter Advanced Readiness Program
FCC	Federal Communications Commission
FDR	Frequency-Dependent Rejection
FDRCAL	Frequency-Dependent Rejection Calculation
FEC	Forward Error Correction
FLTSAT	Fleet Satellite Communications
FM	Frequency Modulated
FPA	Federal Power Agency
FRRS	Frequency Resource Record System
FRS	Fleet Replacement Squadron
FSK	Frequency Shift Keying
G/A	Ground-to-Air
G/G	Ground-to-Ground
G/T	Gain-to-Temperature Ratio
GA	Ground Antenna
GBS	Global Broadcast Service
GBU	Guided Bomb Unit
GCCS	Global Command and Control System
GCCS-M	Global Command and Control System – Maritime
GCS	Ground Control System
GEOSAT	Geostationary Satellite
GFO	GEOSAT Follow-On
GHz	Gigahertz
GMF	Government Master File
GMSK	Gaussian Minimum Shift Keying
GOES	Geostationary Operational Environmental Satellite

GPRS	General Packet Radio Service
GPS	Global Positioning System
GRDCS	Gulf Range Drone Control System
GSM	Global System for Mobile Communications (or Groupe Speciale Mobile)
GTS	Guam Tracking Station
HCLOS	High Capacity Line of Sight
HNA	Host Nation Agreement
HP	High Power
HPA	High Power Amplifier
HTS	Hawaii Tracking Station
Hz	Hertz
I/N	Interference-to-Noise Ratio
ID	Identification
IDN	Instrumentation Datalink Network
IEEE	Institute of Electrical and Electronics Engineers
IF	Intermediate Frequency
IITRI	Illinois Institute of Technology (IIT) Research Institute
IMT-2000	International Mobile Telecommunications for the Year 2000
INMARSAT	International Maritime Satellite
IR	Infrared
ISEM	Inverse Smooth Earth Model
ISM	Industrial, Scientific, and Medical
ISR	Intelligence, Surveillance, and Reconnaissance
ISYSCON	Integrated System Control
I_t	Interference Threshold
ITCS	Integrated Target Control System
ITFS	Instructional Television Fixed Service
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector
ITU-T	ITU Telecommunication Standardization
J/F 12	DD Form 1494, Application for Equipment Frequency Allocation
JSC	Joint Spectrum Center
JTCTS	Joint Tactical Combat Training System
JTF-CS	Joint Task Force – Civil Support
JTIDS	Joint Tactical Information Distribution System
JTRS	Joint Tactical Radio System
kb/s	Kilobits per Second
kbps	Kilobits per Second
ksps	Kilosymbols per Second
kHz	Kilohertz
km	Kilometer

LAMPS	Light Airborne Multipurpose System
LAN	Local Area Network
LEO	Low-Earth-Orbit
LEO&A	Launch, Early Orbit Operations and Anomaly Resolution
LOS	Line of Sight
LP	Low Power
LPD	Low Probability of Detection
LPE	Low Probability of Exploitation
LPI	Low Probability of Intercept
LRIP	Low-Rate Initial Production
m	Meter
MB	Mainbeam
Mb/s	Megabit per second
Mbps	Megabit per second
MCAS	Marine Corps Air Station
MCC	Mission Control Complex
MCEB	Military Communications-Electronics Board
MCS	Master Control Station
MDS	Multipoint Distribution Service
MEF	Marine Expeditionary Force
MEO	Medium Earth Orbit
MHz	Megahertz
MMDS	Multichannel Multipoint Distribution Service
MOD	Modified
MS	Master Station or Monitor Station
MSE	Mobile Subscriber Equipment
MSK	Minimum Shift Keying
MSX	Midcourse Space Experiment
MTACS	Multi-Object Tracking and Control System
MTC	Major Training Center
MUOS	Mobile User Objective System
MW	Microwave
MW	Milliwatt
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Air Systems Command
NAVSOC	Naval Satellite Operations Center
NAWCAD	Naval Air Warfare Center Aircraft Division
NB	Narrowband
NCA	National Command Authorities
NDAA-99	National Defense Authorization Act of 1999

NDAA-00	National Defense Authorization Act of 2000
NDI	Non-Developmental Item
NDS	Nuclear Detonation Detection System
NF	Noise Figure
NHS	New Hampshire Station
NIMA	National Imagery and Mapping Agency
nmi	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-Orbiting Operating Satellite System
NPRM	Notice of Proposed Rulemaking
NRZ	Non-Return-to-Zero
NRZ-L	Non-Retrun-to-Zero-Level
NSAWC	Naval Strike and Air Warfare Center
NTIA	National Telecommunications and Information Administration
NUDET	Nuclear Detonation
OAS	Onizuka Air Station
OBRA-93	Omnibus Budget Reconciliation Act of 1993
OC	Operational Center
OCONUS	Outside the Continental United States
OOBE	Out-of-Band Emissions
OQPSK	Offset Quadrature Phase Shift Keying
OSD	Office of the Secretary of Defense
PAM	Pulse Amplitude Modulation
PCM	Pulse Code Modulation
PCS	Personal Communications Services
PGM	Precision Guided Munitions
PM	Phase Modulation
PSK	Phase Shift Keying
QPSK	Quadrature Phase Shift Keying
R&D	Research and Development
RF	Radio Frequency
RFI	Radio Frequency Interference
RHCP	Right Hand Circular Polarization
RPV	Remotely Piloted Vehicle
RS	Reed-Solomon
RTS	Remote Tracking Station
RTT	Radiotransmission Technology
Rx	Receiver
S/(I+N)	Signal-to-Interference plus Noise Ratio
S/N	Signal-to-Noise Ratio

SA	Situation Awareness
SAR	Search and Rescue
SATCOM	Satellite Communications
SATOPS	Satellite Operations
SBIRS	Space-Based Infrared System
SCADA	Supervisory Control and Data Acquisition
SCT	Single Channel Transponder
SEM	Spherical Earth Model
SFARP	Strike-Fighter Advanced Readiness Program
SGLS	Space Ground Link Subsystem
SL	Sidelobe
SLAM-ER	Standoff Land Attack Missile – Expanded Response
SMC/TE	Space and Missile Center/Test and Evaluation
SOH	State of Health
SRI	Stanford Research Institute
SS	Spread Spectrum
STDN	Space Tracking and Data Network
STGS	S-band Transportable Ground Station
STS	Space Transportation System
SV	Space Vehicle
T&E	Test and Evaluation
TACAN	Tactical Air Navigation
TACTS	Tactical Air Combat Training System
TAS	Target Acquisition System
TCM	Trellis Coded Modulation
TCTS	Tactical Combat Training System
TCU	Tracking and Communications Unit
TDMA	Time Division Multiple Access
TIREM	Terrain Integration Rough Earth Model
TIS	Tracking Instrumentation Subsystem
TOC	Tactical Operations Center
TOSS	Television Ordnance Scoring System (TCM-601)
TRI-TAC	Tri-Services Tactical Communications
TRR	Tactical Radio Relay
TST	Transportable S-band Terminal
TSTR	Transportable Space Test and Evaluation Resource
TSV	Thru Site Video
TT&C	Telemetry, Tracking, and Commanding
Tx	Transmitter
TY$	Then Year Dollars
TY$B	Then Year Dollars in Billions
TY$M	The Year Dollars in Millions
UAV	Unmanned Aerial Vehicle

UFO	UHF Follow-On
UHF	Ultra High Frequency
US	United States
US&P	United States and Possessions
USB	Unified S-band
USJFCOM	United States Joint Forces Command
USMC	United States Marine Corps
USNDS	United States Nuclear Detonation Detection System
VTS	Vandenburg Tracking Station
W	Watt
WARC-92	World Radiocommunication Conference of 1992
WB	Wideband
WCDMA	Wideband Code Division Multiple Access
WGS	Wideband Gapfiller Satellite
WLAN	Wireless Local Area Network
WMD	Weapons of Mass Destruction
WRC 2000	World Radiocommunication Conference for Year 2000
WSMR	White Sands Missile Range

1.0 INTRODUCTION

1.1 BACKGROUND

In recent years, mobile wireless telecommunications systems have experienced a growth that is matched by few other technologies. Large-scale mobile wireless common carrier services began with cellular systems, sometimes referred to as first-generation systems. Subsequently, second-generation systems, Personal Communications Services (PCS), provided many enhancements to cellular-type service. Advances in technologies have led to the development of advanced wireless technologies, sometimes referred to as third-generation (3G) services or International Mobile Telecommunications for the Year 2000 (IMT-2000). Recently, the World Radiocommunication Conference 2000 (WRC 2000) identified several frequency bands that administrations are urged to consider when developing additional advanced mobile communications services.

The frequency bands identified by WRC 2000 to support advanced mobile communications services include, but are not limited to, 698-960 MHz, 1710-1885 MHz, and 2500-2690 MHz. In the United States (US), a Presidential memorandum mandated that the IMT-2000 studies focus on the two higher frequency bands. However, 1755-1850 MHz is allocated exclusively to Government Fixed and Mobile Services. Many Executive Branch agencies make substantial use of the 1755-1850 MHz frequency range for fixed and mobile operations. Without question the predominant single user of the 1755-1850 MHz band is the Department of Defense (DoD).

The DoD employs the 1755-1850 MHz band to support a broad range of critical mobile/transportable systems, all DoD space systems, a large number of installation infrastructure services, as well as advanced wireless systems in development that are aimed at providing capabilities to support 21st century US warfighting. Major functions supported in the band include Satellite Operations (SATOPS), Tactical Radio Relay (TRR), Air Combat Training System (ACTS), Tactical Control Links/Precision Guided Munitions (PGMs), and other systems. Specific systems include, but are not limited to, the Space Ground Link Subsystem (SGLS) which provides launch, deployment, and telemetry, tracking and commanding (TT&C) of vital military satellite systems, Mobile Subscriber Equipment (MSE) and Digital Wideband Transmission System (DWTS) which support tactical communications, and the Air Combat Training Systems (ACTS) and the Joint Tactical Combat Training System (JTCTS) used to support air combat training.

In an October 2000 Memorandum, the President directed federal agencies to participate and cooperate in the activities of a government-industry effort (led by the Secretary of Commerce in cooperation with the

Federal Communications Commision (FCC)) to identify spectrum for 3G. As part of this effort, federal agencies have been asked to examine their use of the 1755-1850 MHz frequency band and to assess the prospects for sharing spectrum with IMT-2000 systems. The DoD is complying with this request by identifying all DoD systems that operate in the band of interest, assessing the technical feasibility of sharing, examining the operational impact of sharing and/or relocation, and quantifying cost issues associated with sharing and/or relocation. This report presents an assessment of the issues associated with sharing and/or relocation by examining technical, operational, and cost issues associated with selected DoD systems and several notional candidate IMT-2000 systems. While there is commercial interest in worldwide deployment of IMT-2000 services, the focus of this effort was primarily sharing issues in the US and possessions (US&P).

1.2 OBJECTIVE

The objective of this effort was to perform an assessment of technical, operational, and cost issues associated with incumbent DoD systems in the US&P and the possible introduction of IMT-2000 mobile wireless systems into the 1755-1850 MHz frequency band.

1.3 APPROACH

The approach used in this effort employed multiple steps to develop a final integrated product with technical, operational, and cost assessments. The initial step was to identify DoD radio frequency (RF) systems that operate in any or all of the 1755-1850 MHz band. The next step was to conduct technical analyses to determine the potential for undesired interactions between DoD systems and IMT-2000 systems. The results of these analyses were then assessed for several band sharing/segmentation/vacating scenario options, as described below. Based on the technical interference analysis results and considering each scenario option, DoD elements responsible for using the various systems defined the operational impacts of accommodating IMT-2000 systems into the 1755-1850 MHz band. The final step involved the determination of cost impacts to DoD systems for each of the specific accommodation scenarios.

The first step of identifying all DoD RF systems operating in the subject band was accomplished as follows. An extensive survey was conducted of DoD spectrum management databases to identify all DoD systems with the capability to operate in any portion of the band. Once systems were identified, the “owning” military department was tasked to verify with operational and acquisition/support commands the life-cycle status of the system (operational, obsolete, being replaced, etc.). The final list of valid systems (operational or funded for production) became the basis of all subsequent study efforts.

In addition to building the list of valid systems, the DoD also collected technical and operational data on each of the systems. This information included system radio frequency (RF) waveforms, transmitter parameters, system losses, antenna patterns, antenna pointing angles, siting data, receiver selectivities, and receiver performance criteria. Operational data included such information as geographical locations, link lengths, and platform operating altitudes. Planned system upgrades were also incorporated if available technical data was sufficient to support proper electromagnetic compatibility (EMC) assessments.

The next step was to conduct the engineering analyses of the interactions of DoD systems and IMT-2000 systems. Technical parameters for the RF systems were used, and likely operational scenarios were defined. Then desired and interfering signal levels were predicted at the receivers of interest, and predictions were made with respect to the likelihood of undesired interactions. If undesired interactions were predicted, then distance and/or frequency separations required to prevent interference were calculated. In addition to frequency/distance separations, other potential means to mitigate interference were also identified. The unique aspects of specific system interactions are discussed in the appendices.

In order to conduct the technical interference analyses described above, two interim steps were required. The first interim step was to determine the specific technical parameters for IMT-2000 systems that would be used in the EMC assessments. Since there is no IMT-2000 hardware in production in the US at this time, it was necessary to develop the parameters for the analysis using technical literature, selected aspects of existing wireless mobile systems, and calculations based on communications theory. The basis for the final parameters used in the assessments was a Federal Communications Commission (FCC) document presenting notional characteristics for various technologies that may be used to implement IMT-2000 services.[1] Minor modifications were made to the FCC parameters following discussions between the FCC and DoD technical staffs. The IMT-2000 technical parameters used are presented in Appendix A.

The second interim step necessary to enable the accomplishment of the technical interference analyses was the grouping or clustering of the large number of DoD systems into subsets referred to as “major systems categories.” This grouping of systems was necessary for several reasons. There were over two hundred systems identified as potentially being impacted by the accommodation of IMT-2000 systems in the subject band. The study schedule did not allow sufficient time to conduct individual EMC assessments for each of these systems. In addition to the time constraint factor, a number of the systems

[1] *Spectrum Study of the 2500-2690 MHz Band: The Potential for Accommodating Third Generation Mobile Systems*, Interim Report, FCC, 15 November 2000.

were similar in both mission function and technical capabilities and that a technical interference analysis conducted for one system would be useful in drawing conclusions for multiple similar systems. Lastly, the grouping of systems into logical categories would facilitate the development of a high-level set of study conclusions that would be much more useable for the national decision process. The major categories of systems used for the study follow:

- Space/SGLS systems
- Tactical radio relay systems
- Air Combat Training Systems
- Precision Guided Munitions systems
- Miscellaneous "Other" systems

Once the technical analysis results were available for each of the major system categories, they were used to assess the "technical" feasibility of the DoD systems operating in the 1755-1850 MHz band to accommodate new IMT-2000 systems. The 3G-study plan developed in response to the Presidential Memorandum of October 13, 2000 provides that the FCC and the National Telecommunications and Information Administration (NTIA) will address band segmentation and sharing options. The following options were assessed in this DoD impact study.

- Option 1: Full band sharing (IMT-2000 systems operating anywhere in the 1755-1850 MHz band)
- Option 2: Band segmentation/Partial Band sharing
  - 1755-1805 MHz retained for operation of government systems and 1805-1850 MHz potentially reallocated to non-government use (Option 2A)
  - 1790-1850 MHz retained for operation of government systems, and 1755-1790 MHz potentially reallocated to non-government use as part of a phased sharing approach (1710-1755 MHz available immediately, 1755-1780 MHz available at some mid-term future date, and 1780-1790 MHz would be made available in the long-term). (Option 2B)
- Option 3: Band segmentation and other band combination (Options 3A/3B)
- Option 4: Vacating the Band

The next major step was to identify the operational impacts of the various sharing segmentation options. The results of the technical feasibility sharing analyses were provided to the military commands and operational communities that employ the various systems in accomplishing national security missions. These organizations were tasked to develop the operational impacts to their missions based on the

technical results of each of the sharing scenarios, as well as for the potential scenario of total band loss. The operational impacts for each scenario were also required to be assessed for the three time frames of 2003, 2006, and 2010. The operational impact is defined to be the change from current or planned operational capability (to support combat operations or the ability to be fully prepared, through training and testing, to support combat operations) to the reduced level of operational capability expected once IMT-2000 systems are deployed. The reduced level of operational capability would include, but is not limited to, the applicable effects of sharing, mitigation measures, and/or migration.

Following the technical and operational assessments by major system category, the next step was to perform cost impact studies. These studies were required to address the costs of interference mitigation measures as well as band migration measures for the major systems impacted by each of the sharing scenarios. The cost impacts were developed by acquisition program offices with the participation of operational command representatives and military Service costing organization representatives. To ensure consistency in costing approaches, costing guidelines were provided for all cost efforts by the Office of the Secretary of Defense (OSD) Cost Analysis Improvement Group (CAIG).

The results of each of the three primary assessment efforts, technical, operational, and cost; were then integrated into a synthesized DoD assessment for each of the major system categories and in accordance with the tasked framework of sharing/segmentation/vacating options and the three time periods (2003, 2006, and 2010).

2.0 ESSENTIAL CONDITIONS

The 1755-1850 MHz frequency range supports several functions critical to the DoD mission and the security of the US. The compromise of any of these functions is unacceptable. Congress has recognized the importance of adequate access to radio spectrum to the DoD mission and the security of the US and has enacted legislation to provide particular protections. In particular, the National Defense Authorization Act of 2000 (NDAA-00) directs that DoD shall not surrender use of a band of frequencies of which it is a primary user unless (a) NTIA, in consultation with the FCC, has identified and made available to the DoD for its primary use, if necessary, an alternative band or bands of frequencies with comparable technical characteristics as a replacement, and (b) the Secretary of Commerce, the Secretary of Defense, and the Chairman of the Joint Chiefs of Staff have jointly certified to the Committee on Armed Services and the Committee on Commerce, Science and Transportation of the Senate; and the Committee on Armed Services and the Committee on Commerce of the House of Representatives, that the replacement band or bands of frequencies identified in (a) above provides comparable technical characteristics to restore essential military capability that will be lost when the band of frequencies is surrendered. The following general conditions cannot be compromised during the consideration of this band.

- If a decision is made to vacate all or a part of the 1755-1850 MHz band, the DoD must retain protected access until the last DoD system has migrated. Current regulatory provisions that protect existing DoD operations in the band must continue throughout any migration or transition period.
- DoD must be provided regulatory protection in any new band associated with a reallocation action equivalent to the protection currently provided in the 1755-1850 MHz band.
- DoD systems moving to a new band must receive timely domestic spectrum certification and have reasonable prospect of achieving international coordination consistent with mission requirements.
- During any transition period in which DoD is moving out of the band or a portion thereof, new users would be allowed to operate in the band only to the extent that their operations do not interfere with DoD operations.
- Timely cost reimbursement must be provided to the DoD per NDAA 1999.

- Schedules associated with Program execution cannot be altered.
- Time is a critical factor and at least a decade will be required to implement any changes.

2.1 CONDITIONS FOR SATELLITE OPERATIONS

This report is based on the following conditions with respect to transition or migration of space operations from the 1755-1850 MHz to 2025-2110 MHz band.

- Mission capability provided to end users by US national security space systems will not be degraded. The government will maintain assured access to the 1755-1850 MHz band to satisfy mission objectives until the last 1755-1850 MHz satellite is no longer functioning. This may continue until 2030.
- Domestic regulatory provisions will be implemented so that the DoD has assured access to the 2025-2110 MHz band for Launch, Early Orbit Operations and Anomaly Resolution (LEO&A) and other operations currently operating in the 1755-1850 MHz band. Specifically, the Broadcast Auxiliary Service (BAS) or Electronic News Gathering (ENG) services at transportable and mobile locations shall not claim protection from DoD operations which have been migrated to the 2025-2110 MHz band.
- Current domestic regulatory provisions that protect existing DoD operations in the 1755-1850 MHz band shall continue throughout any spectrum operations migration/transition period.
- DoD obtains appropriate regulatory protections approved national frequency spectrum certifications and assignments in the 2025-2110 MHz band consistent with mission requirements and acquisition timelines.
- The US concludes successful international coordination of DoD satellite networks in the 2025-2110 MHz band.
- DoD determines it is actually possible to successfully conduct satellite command and control operations in the 2025-2110 MHz band.

2.2 CONDITIONS FOR AIRBORNE AND TERRESTRIAL SYSTEMS

The following conditions apply to all other systems with respect to transition or migration from the 1755-1850 MHz frequency band to any other frequency band.

- Mission capabilities provided to military end users will not be degraded. The government will maintain assured access to the 1755-1850 MHz band to satisfy mission objectives until any

capability supported by the 1755-1850 MHz band is successfully accommodated with equivalent regulatory protection in a new frequency band.

- Current domestic regulatory provisions that protect existing DoD operations in the 1755-1850 MHz band shall continue throughout any spectrum migration/transition period.
- DoD obtains appropriate regulatory protections approved national frequency spectrum certifications and assignments in any new frequency bands consistent with the mission requirements and acquisition timelines of affected systems.

3.0 SYSTEM DESCRIPTIONS

3.1 IMT-2000 SYSTEM DESCRIPTION

IMT-2000 and 3G services are the names commonly used to refer to advanced or next-generation mobile wireless telecommunications services. Commercial interests have generally agreed that the 3G family of services, and the systems that will provide them, are intended to reflect a high degree of commonality and are to be compatible with each other. These services will support mobile and fixed users employing a wide range of devices including small pocket terminals, handheld telephones, laptop computers, and fixed-receiver equipment. Some commercial interests envision the 3G services to be ubiquitous throughout the globe, as available in a remote part of a developing country as they are in an urban area in a highly developed country. These entities believe there are significant benefits to manufacturers and users of wireless systems to seamless roaming on a regional and global scale, hence the desire for standardization in system design and service provision for 3G services. The detailed technical parameters of IMT-2000 systems used in this assessment are contained in Appendix A.

3.2 DOD SYSTEM DESCRIPTIONS

The DoD has received spectrum certification for hundreds of communications-electronics systems in the 1755-1850 MHz frequency range and operates many thousands of these systems in the US and abroad. Each of the military services has major, critical systems in this frequency band, as well as important local systems for command and control, security, telemetry, target scoring, video links, and a variety of other functions. This frequency range is used by these critical DoD systems due to a number of factors. The propagation characteristics of the band enable reliable links with low power and low losses as well as excellent penetration of foliage. The band provides wide beamwidths for quick path alignment, inherently allows for inexpensive system components, enables simple equipment set-up methods, and supports highly mobile applications. Table 3-1 identifies some of the major systems and the functions the systems support.

Within the time and resources available for this assessment it was not possible to address all of the DoD systems certified to operate in the 1755-1850 MHz band. Several critical systems were selected for the assessments to help establish the scope of compatibility issues associated with the possible sharing of the frequency band. Overviews of these systems are provided below. Detailed descriptions and the technical parameters used in the assessments are presented in the associated appendix.

Table 3-1. Examples of DoD Systems Operating in the 1755-1850 MHz Band

System Name	Function
Space Ground Link Subsystem	Satellite telemetry, tracking, and command
Some Typical Satellite Systems GPS Milstar Defense Meteorologica Satellite Program (DMSP) Defense Support Program (DSP)	 Navigational and Precise Time Data Satellite Communications Meteorological, oceanographic Missile launch detection
AN/GRC-103	Tactical radio relay
AN/GRC-226	Tactical radio relay
AN/GRC-245	Tactical radio relay
AN/MRC-142	Tactical radio relay
AN/SRC-57	Tactical radio relay
Tactical Air Combat Training System	Air combat training
Air Force ACTS	Air combat training
Joint Tactical Combat Training Systems	Air combat training
Tactical Control Links/PGM	Control of precision strike weapons
Land Warrior	Wireless local area network for combat troops
AN/DSQ-37	Target scoring system
Combat Identification (ID) for the Dismounted Soldier	Tactical communications
Intrusion Detection System	Perimeter security
Robotics Control System	Wireless remote control

3.2.1 Satellite Operations (SATOPS)

The DoD uses this band as the only communications link for initial contact with newly launched satellites, for early orbit checkout of those satellites and for emergency access to spinning/tumbling satellites. It is also vital for command and control, mission data retrieval, navigational data uploads for GPS, and on-orbit maneuvering of its many satellites in all orbits from low earth to geostationary. The SGLS, the primary component of this network, provides continuous, worldwide, command and control of satellites used for missile warning, navigation, military communications, weather tracking and reporting, and intelligence, surveillance, and reconnaissance (ISR). The information provided by these satellites to our National Command Authority, Combatant Commanders, Military Services, and national level decision-makers is crucial to successful execution of our national strategies. Additionally, other federal government agencies, such as the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), the Federal Emergency Management Agency, state and local governments and the commercial sector benefit from the capabilities of the satellites controlled by this network.

3.2.2 Tactical Radio Relay

The Army, Navy, and Marine Corps operate tactical communications systems in this frequency band providing high capacity, digital information to the battlefield. These systems are described below.

3.2.2.1 Mobile Subscriber Equipment (MSE)

The AN/GRC-103, AN/GRC-226, and AN/GRC-245 Radio Sets are line-of-sight (LOS) trunk radios used to link nodes (switching centers) in the Army's tactical telecommunications system or the Army Common User System (ACUS). These radios operate in the 1755-1850 MHz spectrum band. The ACUS is a seamless, tactical communications system that provides secure, highly reliable voice and data communications for both mobile and fixed elements in a tactical or battlefield environment. The ACUS operates from the front-line maneuver battalions to theater headquarters in rear areas. This communication network is formed in two parts: the MSE and the Tri-Services Tactical Communications (TRI-TAC) system. The MSE system is deployed from the corps-level headquarters to the maneuver battalions and the TRI-TAC system is deployed from corps-level headquarters to higher levels of command. These systems provide a digital microwave backbone to link mid level and lower level battlefield commanders with upper level theater decision-makers. The system operates like a high-capacity PCS with rapidly transportable base stations. A corps-size deployment could deploy twelve or more microwave links depending on the operational or exercise scenario. From command and control traffic to intelligence imagery, logistics, medical, and morale and welfare support, MSE provides the battlefield commanders the ability to maintain effective control over their forces. MSE is a tactical system designed for rapid deployment in the field. This is because headquarters units, with their signature electronic emissions, are targeted for artillery and missile attacks by the enemy. The ability to set up, establish a link to higher headquarters and subordinate units and then take the link down and move is key to the survivability of the headquarters units and supports the concept of maneuver warfare. The microwave radio equipment and antennas are transportable and robust for field conditions. To maintain the operator's capability to quickly establish a tactical microwave link, continuous field training is required.

3.2.2.2 Digital Wideband Transmission System (DWTS)

The Navy/Marine Corps DWTS provides a backbone digital communications capability supporting amphibious operations and ground combat operations. The system supports command, control and data transfer from the Marine Expeditionary Force (MEF) level down to the regimental level. The AN/MRC-142 is the Marine Corps element of this radio system providing the digital backbone services (voice,

video and data). This link is the only transmission media available to the Marine Corps with sufficient bandwidth to carry large quantities of critical data such as maps, overlays, intelligence pictures, and other data to the battlefield commanders. The Navy ship-to-shore link of DWTS is the AN/SRC-57 radio. This link is essential for amphibious operations where most of the critical information flow is from the ship to the landing forces. Like ACUS/MSE, DWTS is a tactical system designed to quickly establish microwave links in support of combat operations and maneuver warfare.

3.2.3 Air Combat Training Systems (ACTS)

3.2.3.1 Tactical Air Combat Training System/Aircrew Combat Maneuvering and Instrumentation (TACTS/ACMI)

TACTS/ACMI is a complex system of hardware and software components configured and interfaced to measure, monitor, process, communicate, store, and display weapon and aircraft information in real-time to provide realistic training for tactical aircrews. The US Air Force uses ACMI while TACTS supports the US Navy and Marine Corps. TACTS/ACMI is comprised of airborne and ground-based components linked through RF communications and operates within many prescribed training ranges in the US. The TACTS/ACMI supports training aircrews in realistic warfighting scenarios. It supports simultaneous engagement of multiple air combat participants in state-of-the-art air-to-air, air-to-ground, ground-to-air, and electronic warfare (EW) environments. The system provides real-time monitoring, tracking and recording of the training activities and includes post mission reconstruction capabilities so that crews can receive accurate debriefing and critique of their mission thereby maximizing the benefit of the training activities. The system provides aircrew training such as Aircraft Handling Capability, Basic Fighter Maneuver, or Intercept and Air Combat Training sorties up to and including large composite force training. TACTS/ACMI is the primary tool at virtually all air combat training ranges and supports every level of training from initial schools where pilots first learn to fly the aircraft they will take into battle to advanced tactics training schools that hone combat skills. Typical training bases, such as Luke AFB, AZ, can average 200-plus sorties a day on their instrument range. To ensure interoperability, training sorties are also conducted with Allied Forces, both inside and outside of the US.

3.2.3.2 Joint Tactical Combat Training System (JTCTS)

JTCTS is being developed as the next generation of aircrew training system. JTCTS will fulfill the same functions as TACTS and will provide added flexibility to support “rangeless” training that the current TACTS and certain ACMI systems cannot. JTCTS will employ the GPS for position determination, thereby reducing the requirements for ground support infrastructure and allowing training to be

accomplished without the need for a robust system of ground reference stations. The current JTCTS development program is being restructured due to technical issues. When finished, JTCTS will support more robust inter-service training, as the Services become more interdependent.

3.2.4 Tactical Control Links/Precision Guided Munitions

Tactical Control Links that support PGMs, like the Navy/Marine Corps Standoff Land Attack Missile-Expanded Response (SLAM-ER) and the Air Force Air-to-Ground Missile-130 (AGM-130) and Guided Bomb Unit 15 (GBU-15), provide a decisive combat edge to US forces. These weapons provide the capability to attack single targets with one aircraft or one standoff weapon with greater probability of success than by flying waves of aircraft dropping iron bombs. PGMs increase aircrew survivability by allowing the launch of weapons outside of any enemy anti-air system threat envelope, thereby significantly decreasing aircrew vulnerability. PGMs require regular testing and training in the continental US (CONUS) sites by operational units to maintain operational readiness. Developmental activities also require regular testing as the PGMs are updated for new missions, threats, and capabilities. As documented in air campaigns such as those conducted in Iraq and Kosovo, PGMs were key in the destruction of high value and highly defended targets with little or no collateral damage and aircraft losses. The combatant commanders require this capability to successfully accomplish any mission requiring the use of force.

3.2.4.1 SLAM-ER

The SLAM-ER program builds on the existing Harpoon and baseline SLAM weapon systems. SLAM is a fielded system with proven combat performance in Operation Desert Storm and Bosnia, while SLAM-ER is intended to provide dramatic weapon system performance improvements. The benefits gained from this retrofit are doubled flight range, communications range, and warhead penetration; improved lethality, countermeasures resistance, target coverage, aimpoint selectivity, and accuracy; with a much simpler mission planning and cockpit interface. SLAM-ER has provisions to store up to three pre-planned missions, including Automatic Target Acquisition missions, and one Target of Opportunity mission. Pre-planned missions are developed for fixed land targets or ships in harbor. Pre-planned missions take into account known defenses and terrain. Target of Opportunity missions are generally used for relocateable targets in both land attack missions and Anti-Surface Warfare ships-at-sea missions.

3.2.4.2 AGM-130 & GBU-15

In particular, the AGM-130 and GBU-15 precision guided weapons[2] were designed for employment against fixed, high-value targets in all weather conditions, day or night. These weapons, in the 2000-pound class of weapons, are launched from F-15E aircraft from either low or high altitude at ranges from 5 to in excess of 30 nautical miles. Equipped with TV or Infrared sensors and aided by GPS, these weapons provide operators the ability to attack targets in all weather conditions, day or night. These weapons can be controlled from either the launch aircraft or a standoff aircraft at a range of more than 100 nautical miles. Operators require access to video and command link frequencies at any time during the mission, including ground operations, post take-off pre-launch operations, and post-launch weapon flight operations. Access to the RF spectrum is critical during all training and testing operations-these operations require use of the frequencies for two hours per mission.

3.2.5 Other Systems

The operations of a number of additional DoD systems rely on spectrum between 1755 and 1850 MHz in addition to those of the four primary DoD functional capabilities. Long-range point-to-point microwave system operations represent a majority of the systems. These systems primarily operate at fixed locations and employ directional antennas. A number of mobile operations are also authorized in this band. Two mobile systems, the Combat Identification for the Dismounted Soldier (CIDDS) and the Land Warrior Local Area Network (LAN), are developmental systems whose operations also are dependent on spectrum in this band segment. Land Warrior is a first-generation integrated fighting system for dismounted soldiers. A number of Unmanned Aerial Vehicles (UAVs) such as the Pointer (FQM-151A) and the Exdrone (BQM-147A) are authorized to operate in this band. These systems transmit video and status data from the UAV to the ground control system (GCS) using analog frequency modulated (FM) video and data on subcarriers. Fixed point-to-point microwave, CIDDS, the Land Warrior LAN, and UAVs are believed to represent significant other uses of the 1755 to 1850 MHz band.

3.2.5.1 Corps of Engineers

The Army Corps of Engineers (ACE) operates a nation-wide system of fixed point-to-point microwave links providing connectivity for monitoring water levels, remote alarms, and communications for remote

[2] *Case Study: Impact Assessment on Precision Strike Weapon Data Link Systems to Accommodate IMT 2000*, Eglin AFB, FL: USAF, 5 January 2001. This case study is provided as reference material with the electronic version of this document.

locks, dams, and other water systems. This system provides microwave links where no commercial communications connectivity exists. This system is essential to the ACE operations because it allows for remote monitoring of critical waterway operations negating the need for full time, on-site personnel. The systems provide key maintenance parameters, alarm indications, and provide personnel at the facility with communications capability. The system helps ensure the safety and integrity of the nation's waterways and helps prevent catastrophic events that could cost lives and economic damage as well as environmental damage.

3.2.5.2 Land Warrior

The Land Warrior system is a close combat communications system for infantrymen, combat medics, combat engineers, forward observers, and scouts. With Land Warrior, the soldier can both send and receive voice, video images, map overlay information, operational plan diagrams, etc. The system provides situation awareness information among all team members, improves survivability and increases mission effectiveness while reducing the soldier's equipment load. Current program documentation indicates a minimum of 41,000 units, with a potential increase to 71,000 units, are to be produced commencing in calendar year 2003.

3.2.5.3 Combat Identification of the Dismounted Soldier

The purpose of CIDDS is to help prevent friendly forces from firing on friendly forces, otherwise known as fratricide. CIDDS employs a laser interrogator with an RF response to provide identification of friendly forces by individual and automatic weapons users to a range of over 1000 meters, depending on visual conditions. Forward combat forces, in both open terrain and urban areas, use the system. The laser interrogation signal message identifies a set of random frequency channels, spaced throughout the 1755-1850 MHz band for the transponder to use in its response. Current program documentation indicates approximately 100,000 CIDDS units will be procured to outfit dismounted soldiers of all three military services. CIDDS entered into development in 1997 and the low-rate initial production of fifty units will be tested in FY01.

3.2.5.4 Pointer Unmanned Aerial Vehicle

The Pointer UAV is a production-ready, electric, hand-launched UAV designed for remote monitoring and surveillance. The UAV transmits real time images taken by a black and white, color or thermal camera. A variety of alternative payloads such as air pollution sensing, chemical weapons detection,

and unexploded land mine detection are currently being developed. The video link operates in the 1755-1850 MHz frequency band.

3.2.5.5 Aberdeen Test Center

The Aberdeen Test Center (ATC) Range Telemetry System provides a multi-link radio telemetry communication capability throughout the many test ranges and facilities of the ATC. It consists of several fixed receiving stations located at the high-usage ranges/test areas and many transportable (vehicle housed) receiving stations which are employed at any of the multitude of ATC test areas or remote test sites when required to support testing projects. The test mission and workload of the ATC requires daily support by the telemetry system. It is vital to the accomplishment of the test and evaluation of military equipment, primarily combat and tactical vehicles, and many items of support equipment. Testing under dynamic conditions is a requirement, and the telemetry system provides the capability to transfer engineering measurements from the moving vehicle to a data collection center.

3.2.5.6 Television Ordnance Scoring System (TOSS)

The TOSS (TCM-601) system provides a television ordnance scoring capability to range users in support of exercise and test missions at Nellis Range. TOSS is a field proven accurate weapons scoring system with a night scoring capability using infrared cameras. Scoring can be done for live or inert conventional weapons.

4.0 ASSESSMENT APPROACH

The approach used in this effort required multiple steps in order to develop a final integrated product with technical, operational, and cost assessments. The initial step was to identify DoD RF systems that operate in any or all of the 1755-1850 MHz band. The next step was to conduct technical analyses to determine the potential for undesired interactions between DoD systems and IMT-2000 systems. The results of these analyses were then assessed for several band sharing/segmentation/vacating scenario options. Based on the technical interference analysis results and considering each scenario option, DoD elements responsible for the various systems then defined the operational and cost impacts of accommodating IMT-2000 systems into the 1755-1850 MHz band.

4.1 INTEGRATION OF TECHNICAL, OPERATIONAL, AND COST ASSESSMENTS

The compilation and integration of the various technical, operational, and cost assessments for the numerous DoD systems were based on the following approach. At the highest level, the integration framework addressed each major system category (ACTS, Tactical Radio Relay Networks, etc.) by each of the four sharing/segmentation/vacating scenarios. The key technical assessment results from each element of this framework were integrated with any applicable programmatic realities with respect to system life-cycle projections (expected phase-out, replacement or upgrade date, new system fielding dates, etc.) and potential mitigation measures. For each of the major system categories and the various sharing scenarios, the associated operational and cost assessments were then addressed. If the operational and cost assessments varied over the time frames of 2003, 2006, and 2010, they were included as distinct potential impact situations.

4.2 TECHNICAL ASSESSMENT APPROACH

The goal of this effort was to assess the potential for sharing in the 1755-1850 MHz frequency band from a technical perspective. Assessments were two-way assessments in that analysts considered both interference from DoD systems to IMT-2000 receivers and interference from IMT-2000 emitters to DoD receivers. The general technical approach was to predict undesired signal power at victim receivers by considering appropriate interfering transmitter parameters, operational configurations, coupling between systems considering antenna orientations and propagation losses, and frequency-dependent rejection when appropriate. Undesired received power levels and victim receiver interference thresholds were then used to assess the potential for interference. Interference thresholds may be either interference-to-

noise ratios, desired signal-to-interference plus noise ratios, or the degradation of link margins needed to sustain acceptable bit or symbol energy-to-noise power densities. Desired signal levels were either calculated or provided by system users based on their experience with the design and use of the subject system.

It was recognized that a number of the assessment parameters may not yet be finalized or may vary depending on operational configurations. Consequently parametric assessments were performed in many cases. Many of the appendices contain either multiple figures showing variations in signal levels for different values of selected parameters or tables with multiple entries for similar reasons. Parameters that may vary include, but are not limited to, transmitter power, antenna gain, antenna pointing angles, antenna heights, data rates, receiver selectivities, and desired signal levels.

Implementation of the general technical approach had variations depending on the particular DoD systems being considered. For example, in the satellite operations (SATOPS)-to-IMT-2000 assessment, the primary SATOPS sites are fixed in locations. In this case, a terrain-dependent propagation model could be used to establish received signal level contours around the SATOPS earth station sites for various IMT-2000 base stations and mobile units. Multiple contours are provided in Attachment 1 to reflect variations in receive system parameters and different SATOPS transmit powers and antenna elevation angles.

In the case of mobile or transportable DoD systems, terrain-dependent propagation modeling was not appropriate and a smooth-earth propagation model was used. Also in these cases, this initial assessment tended to place mobile and transportable units at distance separations or altitudes that either reflected guidance from the appropriate program office or represented communications links that would be operating near minimally acceptable conditions. The latter approach is somewhat conservative and was used principally to bound the limits of sharing issues. In several cases, sharing is investigated where desired signal levels are significantly better than minimally acceptable levels. These cases are so noted in the appendices.

Source-to-victim configurations also varied in the assessments. In some cases one-to-one assessments were performed where the principal source of interference was a single emitter of one system to a single receiver of a victim system. Examples of these cases include a single AN/MRC-142 radio to a single IMT-2000 mobile receiver (Appendix C) and a single IMT-2000 base station emitter to a single ACTS ground receiver (Appendix D). In other cases, assessments addressed many-to-one interactions. Examples of these cases include multiple IMT-2000 emitters to spaceborne SGLS receivers

(Appendix B) and multiple IMT-2000 emitters to DoD aircraft participating in training exercises (Appendix E).

As reflected in the description of IMT-2000 systems, mobile wireless networks are deployed over the period of several years. When appropriate, the assessments considered the notional build-out schedule contained in Table A-7. Consideration of this schedule gives an approximate estimate of when certain systems may be affected, as IMT-2000 networks are built-out in the US. These estimates are not precise and may be subject to debate but they do identify those systems particularly sensitive to large-scale network development such as airborne and spaceborne receivers.

4.3 OPERATIONAL IMPACT ASSESSMENT APPROACH

A four-step process was performed to conduct the operational impact assessment for the introduction of IMT-2000 systems into the 1755-1850 MHz band. The first step was to define the system capabilities and associated mission for each of the major systems. Subsequently, DoD analysts assessed system and programmatic changes dictated by the possible introduction of IMT-2000 systems. The next step was to develop and distribute a series of questions to assess system impact based upon a previously identified set of operational scenarios and IMT-2000 phase-in schedules. These questions were sent to the appropriate program offices, Services, and Combatant Commands. Finally, the responses were compiled and analyzed.

The evaluation of operational impacts included an assessment of the effects resulting from changes to operating parameters, or procedures, and possible changes to concepts of operation. The evaluation also addressed the effects of radio frequency interference (RFI), RFI mitigation techniques employed, and possible changes to system hardware and/or software.

The system impact assessments were based upon the introduction of IMT-2000 systems in years 2003, 2006, and 2010 for each of the four options identified in Section 1.3, i.e., full band sharing, band segmentation, band segmentation and combination with other bands, and vacating the band.

4.4 COST ASSESSMENT APPROACH

To determine the cost of transitioning incumbent DoD systems to a new band or the cost of some other means of interference mitigation to 3G systems, it was first necessary to develop a program management plan for implementing the transition. Since DoD will not accept operational degradation caused by the introduction of 3G systems, any proposed program plan must ensure current levels of operational

capability are maintained. Furthermore, any proposed plan must be realistic in the sense of execution, schedule, and risk. Additionally, since little is known regarding availability and location of possible bands that DoD could relocate its systems to, assumptions must be made in this regard to carry out the costing activity. It should be recognized that the costs are sensitive to the band selected and, to the extent that the assumptions made turn out not to be the case, the costing activity may require refinement. The methodology used to develop the estimates for cost reimbursement follow generally accepted cost estimation practices used within the DoD and is consistent with the approach to cost reimbursement proposed in the NTIA's Notice of Proposed Rulemaking (NPRM) on Mandatory Reimbursement Rules for *Frequency Band or Geographic Relocation of Federal Spectrum-Dependent Systems* (published in the Federal Register on January 17, 2001). The cost estimates developed are meant to be preliminary and representative, however, not conclusive. The costs reflect estimated funding for the candidate relocation bands and time frames assumed for relocation.

5.0 CRITICAL ASSUMPTIONS

The following assumptions were key to the assessment process and the study results.

5.1 OVERALL STUDY ASSUMPTIONS

- Equipment/system modifications or physical relocations to support sharing, segmentation, or vacating the band would not occur by the 2003 time frame due to the time required for program budgeting, and contract preparation, award, and execution.
- Scenarios were not considered feasible if they resulted in a degradation of operational capability for DoD systems.

5.2 TECHNICAL ASSUMPTIONS

- Systems grouped into major system categories (except "Other") demonstrate similar radio frequency interactions with IMT-2000 systems.
- Transportable, mobile and airborne DoD systems are assumed to operate over the full geographic area of their associated military installations (i.e., emitters could be located along the installation boundary).
- Aggressive schedules for system modifications, upgrades, or replacements were considered high risk and unlikely to be successful.

5.3 OPERATIONAL ASSUMPTIONS

- US Armed Forces are vital to the security of the US and require assured spectrum access to perform their missions.
- The ability of US Armed Forces to conduct operations and train in the US is essential to maintaining effective combat capabilities.
- US Armed Forces must be able to operate and train with systems in the US the same way these systems would be employed in the full range of missions worldwide.
- The loss of operational capability is directly linked to the potential for failure on the battlefield.
- Whatever mitigation techniques are implemented, they cannot restrict DoD systems from meeting mission requirements, i.e., DoD systems must maintain the flexibility to support current operations.
- Warfighting capabilities provided by systems addressed in this report (e.g., SATOPS, PGMs, etc.) are essential elements of the combatant commanders' ability to complete their missions.

5.4 COST ASSUMPTIONS

- Cost estimates for all systems and scenarios are preliminary and representative, not conclusive. The costs reflect estimated funding for the candidate relocation bands and time frames assumed for relocation.
- All costs are presented in Then Year dollars (TY$).
- The methodology for cost estimates follows generally accepted cost estimation practices of the DoD and is generally consistent with the cost methodology set forth in the January 17, 2001 NTIA cost reimbursement NPRM.
- Costs are sensitive to band selection and will require revisiting upon actual band determination.
- Additional manpower, where required, was included in some cost figures.
- For satellite control systems, it was assumed that no matter to what extent the 3G systems are built out, the SGLS link will remain viable. Therefore, the costs shown assume that no DoD satellites nor supporting infrastructure will require accelerated or premature replacement due to a lost TT&C link. If the SATOPS link becomes unusable at some point and, therefore, some DoD satellites will need replacing and ground infrastructure will need modifications, the costs will increase significantly relative to those presented here.

5.5 SCHEDULE ASSUMPTIONS

- Dates identified for DoD accommodation of IMT-2000 are predicated on funding for programmatic actions being available in FY02.

5.6 IMT-2000 ASSUMPTIONS

- The technical parameters describing IMT-2000 equipment used in this report are a reasonable representation of several candidate IMT-2000 systems that may be deployed in US markets.
- The spectrum requirements defined in ITU-R Report M.2023 reflect a reasonable estimate of the deployment of IMT-2000 systems at full build-out.
- IMT-2000 networks will mature over the course of several years with urban areas maturing first.
- On occasion IMT-2000 base station and mobile receivers may operate near minimally acceptable performance levels.

5.7 SATOPS ASSUMPTIONS

- SATOPS minimum antenna elevation angles may fall between 3 and 5 degrees above the horizon.
- SATOPS uplink transmitter powers may range from 100 watts to 10 kW.
- Existing emission spectra and frequency plan of current SATOPS uplinks are as defined in the SATOPS system description.
- SATOPS earth station antennas must support 360° azimuthal coverage.
- All spacecraft launched after 2010 will be Unified S-band (USB) capable.
- A space-qualified SGLS/USB capable commercial-off-the-shelf (COTS) transponder that meets DoD communication security (COMSEC) and other requirements will not be available for integration before July 2004. A transponder with program specific capabilities will not be available until 2005. This assumes the decision to proceed with the transponder program will be by July 2001.

5.8 TACTICAL RADIO RELAY ASSUMPTIONS

- Transmitter and receiver sites may occur anywhere within selected training ranges.
- National Guard and Reserve units will regularly train with radio relay systems at appropriate sites throughout the country.
- Tactical radio relay systems may occasionally operate near minimally acceptable performance levels.
- The AN/GRC-245 radio would be available in sufficient quantities to replace the AN/GRC-226 radio and the AN/GRC-103 radio before 2010.
- A new radio could be developed to support the DWTS function at frequencies above 2 GHz. However, the antenna beamwidths at higher frequencies would be much narrower than those provided by the current band. Operational needs would require the development of new antenna technology to support these mobile command and control links.

5.9 ACTS ASSUMPTIONS

- Areas around two training ranges, Cherry Point Marine Corps Air Station (MCAS) in the eastern US and Nellis Air Force Base (AFB) in the western US, may be considered typical locations for determining IMT-2000 aggregate environments to ACTS airborne receivers.
- For determining desired signal levels at airborne receivers, 35 km and 78 km separations from the ground transmitters are typical and near-maximum values, respectively, for the

TACTS/ACMI. For the JTCTS, air-to-air transmitter-to-receiver separations of 78 km and 278 km are typical and near-maximum values, respectively.

- The 9000 m altitude used for the analysis is a typical aircraft altitude used for flight training, although some altitudes as great as 20,000 m may be necessary.
- ACTS ground station antenna heights of 30 m are typical or near-maximum values.
- Specified maximum communications ranges and other capabilities of the ACTS are to remain unchanged, as system components are redesigned to operate in frequency bands different from those presently used.

5.10 TACTICAL CONTROL LINKS/PGM ASSUMPTIONS

- Operation without interference at the pod-to-terminal separation distance analyzed in the classified appendix (Appendix F) is a requirement.
- Pod and terminal altitudes can be between ground and 30,000 ft above ground level.

5.11 OTHER SYSTEM ASSUMPTIONS

- Army Corps of Engineers Fixed Point-to-Point communications antenna towers are typically no more than 80 m in height.
- Permanent frequency assignments recorded for Army Corps of Engineers Fixed Point-to-Point communications operations are indicative of actual use (i.e., that 1755 to 1850 MHz and 1710 to 1755 MHz microwave links have not been replaced with other communications media as yet).
- Locations where the Land Warrior LAN and CIDDS will operate lie within all DoD test, training, and operational areas within the US.
- Size, weight, and power will have to be minimized because of the small size of the UAV.
- The communications link budget must be maintained without added complexity.
- The Pointer and Exdrone altitudes may vary from 0 m to 3280 m above ground level.

6.0 SUMMARY OF RESULTS

6.1 RESULTS FOR CONSIDERED OPTIONS

The accommodation of IMT-2000 services into the 1755-1850 MHz band will have unacceptable impacts to the current DoD systems operating in the band, even if accommodation were deferred until 2010 or beyond. The impacts are unacceptable with regard to the ability of the US military forces that use DoD RF systems to achieve and maintain warfighting readiness. In addition, millions of civil and international users of GPS timing and navigational services will be adversely impacted. Mitigation measures would be required for both DoD systems and IMT-2000 systems for partial accommodation of IMT-2000 services under certain sharing or segmentation options. These measures would have major cost and functional impacts to the DoD and may prove unacceptable as a business case to IMT-2000 service providers. The potential for DoD to transition completely out of the band is not possible for all non-space systems until at least 2010 or later, and for space systems, it is not possible until at least 2017 or beyond. However, the government must maintain assured access to the 1755-1850 MHz band until all legacy systems operating in this band have completed their missions. These missions are expected to last until the 2020-2030 timeframe. Therefore, vacating the band is not possible for the DoD according to IMT-2000 timelines. The cost presented in Table 6-1 for total band loss (Option 4) is according to DoD timelines (2020-2030). Transition out of the band would require cost reimbursement and provision of sufficient bands of comparable spectrum below 3 GHz. Such replacement spectrum must provide primary status and equivalent regulatory protection.

With respect to cost issues, Table 6-1 summarizes preliminary reimbursement cost estimates for the options addressed in this study. Since DoD cannot modify any systems by 2003, and since operational restrictions are considered unacceptable, accommodation of IMT-2000 in this band in that timeframe is not considered feasible, thus no costs are presented. Under any 2003 scenario, the burden of mitigation would need to be borne completely by IMT-2000 systems. For the 2006 timeframe modification of DoD systems could be underway to accommodate band segmentation. However, any migration of DoD systems will not be feasible until at least 2010 or beyond, thus costs are only shown for the 2010 timeframe. Under no schedule is full band sharing considered feasible, thus no costs are shown for that option. All costs presented are extremely sensitive to the critical assumptions outlined in Section 5.

Although the costs of all affected systems are included, the differences between the band segmentation options are preliminary in the affected satellites and their associated ground stations. The portion of the band lost will determine which satellite systems will be unable to utilize SGLS in the future. The biggest single satellite system that is affected by options 2B/3B, but not by options 2A/3A, is GPS.

Because GPS uses the 1755-1850 MHz for its mission data uploads as well as TT&C, the loss of government use of the GPS uplink channel is a major cost driver.

There are many key underlying assumptions for the costs provided in Table 6-1. From a costing perspective, the most important observation is that the numbers in the table represent only one point on a graph of expected cost versus risk. All of the cost figures are very sensitive to many complex technical and budgetary unknowns. Time did not allow for the quantification of these risks and the resulting simulation that would have established the range of cost and the probability of realizing a cost within the range. Based, however, on apparent risk, it would be consistent to expect a significant range of probable cost. Changes in any of the variables, including the development of the IMT-2000 systems themselves, could cause significant changes in the results provided herein. Perhaps the most important assumption is that the DoD will maintain access to this band to satisfy mission objectives until the last 1755-1850 MHz satellite is no longer functioning. This assumption is key because if this was not the case, many DoD satellites would require replacement, increasing the overall cost many-fold. This would be operationally unacceptable because it is unclear when replacement satellites could be developed, built, and launched to maintain DoD satellite system capabilities or if industry even has the capacity to provide these replacement satellites in a timely manner. Another extremely critical assumption underlying the cost figures is that comparable alternate bands are made available for the systems that require relocation, e.g., the weapon links and the tactical radios. If comparable alternate bands are not identified, the DoD would lose the capability provided by these critical systems, which is unacceptable. Finally, secondary and tertiary impacts have not been included in the costs presented. An example of these costs includes increased comparable band coordination costs.

Table 6-1. DoD Cost and Schedule Summary (TY$B)

Full Band Sharing (Option 1)	Band Segmentation Lose 1805-1850 MHz (Option 2A/3A) Notes 1,2,3,4	Band Segmentaion Lose 1755-1790 MHz (Option 2B/3B) Notes 1,2,3,4	Total Band Loss (Option 4) Notes 1,2,3,4
Not Applicable	$2.8	$3.9	$4.3

1 Requires provision of certified comparable spectrum (NDAA 00)
2 Requires cost reimbursement (NDAA 99)
3 Requires protected spectrum access to the band through any transition
4 Complete DoD migration is not possible until beyond 2010 for non-space systems and beyond 2017 for space systems

In summary, since the band sharing option introduces significant operational risks, no costs are presented. The cost to reimburse DoD for the band segmentation options, given the assumptions and mitigation strategies discussed in detail below, is either $2.8B or $3.9B, depending on which option is chosen. If the entire band is lost, the cost would be at least $4.3B; however, total migration of DoD

systems from this band is not possible within any of the dates established by the Presidential study plan and in fact could not be completed until well after 2020.

6.1.1 Full Band Sharing

Full band sharing between DoD and IMT-2000 systems is not feasible due to prohibitive separation distances. The successful simultaneous operation of DoD and IMT-2000 systems in a number of populated regions will be prevented by the interference interactions expected between DoD systems and IMT-2000 systems. It is not known whether the potential impact or possible mitigation restrictions on IMT-2000 systems are acceptable to industry, however those that may be imposed on DoD systems would have unacceptable impacts. These include major limitations on airborne operations involving aircrew training and weapons testing such that military mission requirements could not be met. Tactical communication systems would be limited in operation to only remote areas and even then would require significant coordination efforts. The ground network used for the primary control of critical DoD satellites could be required to limit operational parameters (satellite contact frequency and duration, contact time of day, transmitter power, etc.), which would put the health of all constellations at risk. On-orbit spacecraft would be susceptible to interference from aggregate IMT-2000 system emissions to the point that effective spacecraft control could be lost.

6.1.2 Band Segmentation/Partial Band Sharing

Band segmentation options consistent with those presented in the study plan were assessed. The first segmentation option (Option 2A) evaluated is the accommodation of IMT-2000 systems into the 1805-1850 MHz segment of the band while the government systems maintains its operation in the remaining 1755-1805 MHz portion of the band. This segmentation option with the addition of comparable spectrum (Option 3A) for DoD operations was also considered. Another segmentation option that allowed for a phased entry of IMT-2000 systems was addressed. In this segmentation scenario (Option 2B), government operations would be retained in 1790-1850 MHz while the 1755-1790 would potentially be reallocated to non-government use as part of a phased introduction. The phasing considered allowed IMT-2000 systems to be introduced into the 1710-1755 MHz portion of the band immediately followed by additional access to 1755-1780 MHz at a mid-term future date, and 1780-1790 MHz would be made available in the long term. The final segmentation option (Option 3B) used the same phased availability of spectrum for non-government use and also made additional comparable spectrum available for DoD use.

Options for DoD to vacate certain portions of the 1755-1850 MHz band to IMT-2000 operations will also result in significant impacts to DoD system operations. Accommodation as a result of any segmentation option would take many years and would require cost reimbursement. Absent provision of comparable spectrum (and to date no such comparable spectrum has been identified), all of the DoD major systems in the band would experience serious operating restrictions due to the loss of spectrum access under either of the segmentation options. In order to support adequate mission capabilities, DoD requires access to additional spectrum in the mid 2 GHz area and below on a primary basis with equivalent regulatory protection to 1755-1850 MHz, in order to support large military exercises, aircraft and missile testing, and fighter aircraft combat proficiency training. In addition, specific system acquisition programs would require changes and additional funding to enable DoD systems to ensure operating effectiveness under either segmentation option. These changes include program accelerations, design modifications, and fielding of upgraded systems to installations or units that currently do not plan to field the upgraded capability. While either segmentation option would have impacts to all major DoD systems, the option that would take a phased approach with initial IMT-2000 services in the 1710-1755 MHz portion of the band would reduce the impacts to most systems for a number of years. This would allow time for programs to receive funding through reimbursement to make equipment/band transitions and implement mitigation measures. Elimination of OBRA-93 conditions, i.e., the continued existence of protected federal government sites at a number of locations throughout the US at which DoD operations can continue with the same level of regulatory protection as at present, would result in an immediate impact to PGMs and other systems.

Due to the potential for degradation to operational capability, losing access to any significant portion of the 1755-1850 MHz band without access to additional comparable spectrum and adequate time to withdraw from the specified band is unacceptable to the DoD. If the conditions of full cost reimbursement, on time program execution, and operationally protected use of the spectrum through the course of any necessary transition are met, some band segmentation may be feasible. The feasibility of any segmentation requires the full cooperation of the IMT-2000 industry. This cooperation entails acceptance of DoD transition timelines and DoD's continued unrestricted operation in the existing band during the course of any transition. The timelines for accommodation of IMT-2000 in any significant segment of the 1755-1850 MHz band by the DoD are comparable to those of full band sharing. Given that the above conditions are met, transition by the DoD for this option could not be completed until 2010 or later for the most non-space systems and until 2017 and beyond for the space systems. As in the case of vacating the total band, migration prior to these dates would require premature system termination, which would have extremely serious implications to the DoD's ability to effectively execute its mission. These dates are also predicated on funding availability in FY02.

6.1.3 Vacating the Band

DoD vacating the 1755-1850 MHz band in the near-term would cause serious national security impacts. No amount of funding could mitigate the impacts in the near-term. Terrestrial systems would require at least 10 years (no earlier than 2010) to completely transition out of this band and into a band of comparable characteristics. To date, no bands or combination of bands surveyed by DoD or proposed by NTIA have proven suitable for a relocation of DoD systems currently resident in 1755-1850 MHz. Space systems are not expected to completely transition out of the band until after 2020-2030.

6.2 RESULTS FOR INDIVIDUAL SYSTEMS

6.2.1 Satellite Operations

The ability to support pre-launch, launch and early orbit activities, on-orbit operations, anomaly resolution, and end-of-life management is absolutely critical to satellite control and management. Impact to SATOPS functions is manifested in one of two areas: impact to the spacecraft receiver from IMT-2000 terrestrial emission, and restrictions placed upon the DoD's terrestrial uplink operations to accommodate IMT-2000 operations. Unlike terrestrial-based systems, space-based hardware cannot undergo a frequency change once the hardware is launched. Since all of the DoD satellites rely on SGLS control afforded by the Air Force Satellite Control Network (AFSCN), Naval Satellite Operations Center (NAVSOC), GPS, and DSP networks, continued protected access to the spectrum used by these on-orbit assets is required to maintain control of the satellites and associated mission payloads.

Given that SATOPS functions are performed across the 1755-1850 MHz frequency band, band segmentation or band vacating schemes have unacceptable impacts to existing satellites utilizing the affected portions of the spectrum unless continued protected access is maintained through the course of any transition. Even with assured access, unacceptable impacts to satellite uplink closure reliability are expected starting in 2006 under typical uplink operating parameters. Under certain conditions, increased uplink power may not provide adequate link margin.

Denying SATOPS the spectrum needed to support on-orbit assets will result in a partial or complete loss of TT&C capability. This will result in varying degrees of impact to the spacecraft including orbit-positioning errors, loss of payload control leading to eventual malfunctions and mission failure, and ultimately, complete loss of the satellite. Mission capabilities such as missile warning, navigation, military communications, weather, and intelligence, surveillance and reconnaissance would be severely impacted until such time that a replacement capability could be launched. Failure to support GPS and

weather services satellites not only impacts military operations but also will have adverse consequences for the civilian community.

For all three options, band segmentation, band sharing and vacating the band, the DoD must retain full SATOPS operational capability and regulatory protection to support existing satellite systems until their end-of-life. Mitigation techniques exclusive to the IMT-2000 community such as the establishment of coordination zones (areas surrounding SATOPS uplink sites) allow access to the spectrum without operational impact to the DoD. Other techniques such as IMT-2000 dynamic frequency reallocation may have some operational and cost impacts depending upon the specific implementation.

6.2.2 Tactical Radio Relay

6.2.2.1 Mobile Subscriber Equipment and TRI-TAC

For the band sharing option in the 2003 time frame, the Army must continue to operate MSE and TRI-TAC in the 1755-1850 MHz band for realistic battlefield training. Because there are no material solutions available in this time frame to facilitate sharing, it is anticipated that restrictions on military systems would result, thereby impacting operations as they are conducted today. Restricting transmitter/receiver locations and antenna pointing directions will limit realistic training of units and limits the commanders' ability to realistically deploy signal assets. Restricting training deployments to pre-planned, pre-coordinated sites exercise-after-exercise reduces the microwave operator's combat skills. The learning curve for establishing tactical links in actual deployment situations will be steeper and longer because of the lack of realistic field exercise training. The time required to establish effective command and control, especially in the information intensive battleground today, may be a deciding combat factor.

Army Guard and Reserve component units located primarily in urban/suburban areas with ACUS/MSE and TRI-TAC systems may be severely restricted in training opportunities because of their proximity to IMT-2000 base stations/mobile phone concentrations. If these units are restricted from training operations at home locations, then the units must deploy to the nearest training area thereby imposing increased costs on training that are accomplished today with relatively small investment.

If 3G systems were accommodated in this frequency band, the Army installation Frequency Managers would need to coordinate with IMT-2000 system's operators prior to conducting training exercises. The frequency managers at most of the Army's training ranges are already facing crowded frequency space and further sharing restrictions will make any large-scale exercises unworkable.

For 2006 and 2010, the operational impact to US forces if IMT-2000 systems begin operation in the 1755-1850 MHz band are the same as 2003, unless access to additional spectrum in bands up to 2690 MHz is provided on an primary basis with equivalent regulatory protection. As the High Capacity Line-of-Sight (HCLOS) radios replace the current generation of MSE and TRI-TAC equipment, the additional flexibility in frequency selection could reduce, but not eliminate, the impact resulting from loss of the 1755-1850 MHz band provided access to an equal amount of additional spectrum and operating frequencies between 1850 and 2690 MHz is granted.

By 2003 for the segmentation options, any reduction in available spectrum would further reduce the size and scope of training exercises in training areas where frequency space is already at a premium. Fielding of HCLOS radios would not be sufficient to provide any significant relief in this time frame. Impacts to Army training would be similar to those described in the band sharing option around large training areas; however, impact to Reserve and National Guard units will be minimal if access in the remaining government spectrum is maintained.

For the 2006 time frame, some impact to training is expected, however, fielding of HCLOS radios will improve the situation if access to frequencies up to the mid 2 GHz region is provided on a primary basis with equivalent regulatory protection. By the 2010 time frame, HCLOS fielding should have replaced current generation radios.

Vacating the entire 1755-1850 MHz band is not an acceptable option for the Army. This band is an essential element of Army battlefield communication networks for the foreseeable future, including the new HCLOS radio. Alternate higher frequency bands such as 4.4 – 5.0 GHz, are not suitable for tactical communication systems like MSE. The 1700 MHz band is used for mobile communications because the propagation characteristics allow for penetration of foliage, use of easy to handle coaxial cables instead of expensive and fragile wave guides, and have a wide beam width allowing for quicker path alignment. These characteristics are critical to tactical mobile communications units because of their mission to provide the Army with the ability to relocate command centers quickly. Moving the communications network to a higher frequency band would negate many of these factors, thus decreasing the operational utility of the system. The operational implications from the inability to train in the US would directly impact combat operations.

6.2.2.2 Digital Wideband Transmission System

The Navy/Marine Corps depend on the DWTS for information transfer between ships and troops ashore as well as dissemination throughout the battlefield. There are no replacement radios planned for the DWTS, so continued access to the 1755-1850 MHz band is crucial to amphibious operations training.

Full-band sharing between DWTS and 3G systems and segmentation options result in the same challenges as described previously in the section on ACUS/MSE. Restrictions on DWTS operation that would be expected under a full band-sharing scenario reduce or eliminate the utility of training in the establishment and operation of this vital link.

Limiting the size of exercises severely restricts the utility of training activities. If the Marine Corps could no longer stage MEF/division level exercises, it loses the ability to properly train its troops, and also loses the capability to rehearse for deployments. This reduces the readiness of our warfighters by increasing the time required to establish critical command and control links. Restricting training to certain specified ranges would also severely impact operations. This requires large troop movements to other training locations at an increase in both cost and lost time. This especially impacts the Reserve units, as they would no longer be able to participate in training in areas where the density of IMT-2000 is high, but would have to travel to specified training locations or ranges.

These impacts would be essentially the same in both the 2003 and 2006 time frames. As stated previously, no replacement radio is currently planned, and even if a replacement is leveraged with the HCLOS radio, redesign would be required to meet the Marine Corps requirements for mobility and platform suitability. Any replacement, incorporating the frequency flexibility of the HCLOS radio would not be available in sufficient quantities before the 2010 time frame. If such a program is executable and, if access to frequencies in bands up to the mid 2 GHz range is provided, the impact to amphibious training may be significantly reduced. However, access to frequencies in the low end of the DWTS range must be available to support the ship-to-shore communications requirements.

Vacating in either the 2003 or 2006 time frame would result in severe reductions in operational readiness of troops responsible for amphibious communications. This is not considered a viable option for the Marine Corps. Vacating the band would only be considered viable after a new specific frequency band is identified and a new system is developed, tested and fielded.

6.2.3 Air Combat Training Systems

Full band sharing of the 1755-1850 MHz spectrum with ACTS and 3G systems is not considered to be a viable option. Distance separations needed to preclude interference are substantial. Coordination and scheduling of shared spectrum between DoD training ranges and IMT-2000 is not possible due to complex range operations and the requirement for immediate support of unplanned training exercises. Sharing would limit or preclude large-scale joint training exercises and limit migration to rangeless air-to-air operational training.

No replacement or modified ACTS could be deployed by 2003; thus, it is anticipated that under full band sharing in this time frame, all current TACTS/ACMI would be forced to cease operation or face such restrictions as to render their utility nearly zero. The absence of instrumentation to support live tactical training would result in direct loss of readiness for combat forces.

Current plans call for existing ACTS to be operating well past 2010. Under the current plan, JTCTS would not begin replacing fixed range systems until after 2006, with a replacement schedule into at least the 2010 time frame. However, even with a conversion to JTCTS, there are no mitigation techniques that could be implemented in either JTCTS, legacy ACTS, or IMT-2000 to allow successful co-frequency operation in the same geographic region.

For segmentation Option 2, interference between the ACTS data link and IMT-2000 equipment will occur. The RF interference will adversely affect system operation. Interference with uplink frequencies (1830 and 1840 MHz) will render ACTS airborne instrumentation inoperative while interference with ACTS ground-to-ground RF links could vary with portions of the range becoming inoperative to total system failure. Additionally, there is no current way to limit system operation to a portion of the band; therefore, it must be assumed ACTS operation will adversely affect IMT-2000 systems. This would likely cause severe restrictions to TACTS/ACMI emissions thus significantly reducing system utility.

If the ACTS loses access to the 1805-1850 MHz band in 2006, the impacts would be similar to those described for 2003 unless modification to the existing frequency plan is pursued. A remanufacture of existing ACTS hardware (updating for obsolescence and technology advances) might make operation of the legacy systems within a reduced bandwidth feasible. It is estimated the fielding of the proposed ACTS modifications could be accomplished for all ranges by 2006 provided these modifications begin in FY02. For 2010, the assessment is the same as the assessment provided for 2006 except that risk is reduced based on additional time to deploy. The operational impact can be minimized if no spectrum conflicts arise with other incumbent systems and all the mitigation efforts are completely implemented

by 2006 (schedule risk) or if turnover of the 1805-1850 MHz band is delayed at sites where mitigation measures have not been completed by 2006. The replacement of the legacy ACTS by JTCTS is not scheduled to begin until at least 2008. Any loss of current system use or functionality would impact the training and readiness of the aircrews.

Under Option 3, if IMT-2000 build-out is contained below 1755 MHz until perhaps the 2006 time frame, there would be little impact to ACTS operations during that time. If IMT-2000 equipment is deployed to use frequencies above 1755 MHz, impacts to ACTS would occur. Under the current plan, JTCTS would not begin replacing fixed range systems until after 2006, with a replacement schedule into at least the 2010 time frame. The 2006 time frame would not allow for the replacement of legacy TACTS even with a drastically accelerated JTCTS program. If started soon enough, a modification program for the legacy TACTS may allow it to keep operating in the 1780-1850 MHz band. This may allow sufficient time (i.e., until past 2010) for all legacy ACTS to be replaced by JTCTS. Once suitable spectrum is identified, the ground-to-ground microwave links may be relocated. Operational impact is none, if spectrum conflicts do not arise with other incumbent systems and all the mitigation efforts are completely implemented by 2006 (schedule risk), or if turnover of the 1755-1780 MHz band can be delayed at sites where mitigation measures have not been completed by 2006. Any loss of current system use or functionality would impact the training and readiness of the aircrews.

For vacating the band entirely, one option presented is to upgrade all ACTS ranges and equipment with a GPS tracking capability and replace existing RF hardware with new, state-of-the-art, digital equipment. The 2200-2290 MHz band is congested and unlikely to accommodate ACTS operations. This option could not be implemented by 2003. Therefore, vacating the current band in this time frame would impose unacceptable impact to combat training. One of the above options for moving to an alternate frequency band could possibly be implemented by 2006 with schedule risk or by 2010. However, unless continued operation of legacy ACMI is assured in the interim, operational training for aircrews would be severely restricted.

6.2.4 Tactical Control Links/Precision Guided Munitions

Co-frequency operation under full sharing of this frequency band with IMT-2000 systems could impose significant restrictions on DoD operations because PGMs are not able to operate with IMT-2000 systems on a non-interference basis. To accommodate IMT-2000, a modification to these data links must be made to prevent IMT-2000 systems interfering with the weapon data link in target areas where IMT-2000 systems are established. No replacement systems are currently planned for these PGM systems and until one is fielded, current PGM training must continue to use this frequency band.

Segmentation options are similarly unworkable. Due to the design of this system, any modification would be as complex and costly as vacating the entire band.

If the PGM data links have to vacate the current frequency band in 2003, there would be immediate loss of combat capability to the warfighter. The PGMs could not be used to their full potential due to training shortfalls. These are the only systems that provide precision attack capability from a fighter aircraft, and they represent the vast bulk of the total precision capability from all aircraft. By the end of 2007, all of the weapon control pods, support equipment and 20% of the weapon data terminal inventory could be modified to operate with a new set of frequencies. By the end of 2011, modification of the remaining weapon data terminals could be completed, assuming funding is available by FY02.

6.2.5 Other Systems

6.2.5.1 Corps of Engineers

Since the fixed point-to-point microwave links tend to be in remote areas, sharing should not present a problem. For those links near population centers or IMT-2000 systems, frequency sharing could be coordinated; otherwise, the link will have to be relocated in the spectrum. Band segmentation is acceptable as long as the microwave system is capable of operating in that portion of the band. This should apply to individual links, not the microwave system as a whole. Those links situated in a high-density IMT-2000 environment may need to be relocated in the spectrum. During any relocation, the current link must be kept operational until the new link is ready for cutover to prevent remote facilities from being unmonitored.

6.2.5.2 Land Warrior

Any sharing or segmentation option would require the Army, in conjunction with the IMT-2000 industry, to develop acceptable frequency use coordination procedures. Although this option appears attractive, the restrictions for sharing, such as limiting operations, locations, and link length, may inhibit the full use of this system by the Army. The Army's policy is to train as it fights; thus, limiting the size and scope of the training exercises violates this mandate. Also, Army Guard and Reserve unit training at home locations will be similarly affected. Fully vacating the band requires a system redesign and delays fielding the system.

6.2.5.3 Combat Identification for the Dismounted Soldier

Like Land Warrior, any sharing or segmentation option would require the Army, in conjunction with the IMT-2000 industry, to develop acceptable frequency use coordination procedures with the same impacts. Fully vacating the band requires a system redesign and delays fielding the system. The current operational impact is none, but delaying the fielding of the system may increase the likelihood of continued fratricide during future conflicts.

6.2.5.4 Pointer Unmanned Aerial Vehicle

Sharing may be acceptable and possibly workable but would require the Army, in conjunction with the IMT-2000 industry, to develop frequency use coordinating procedures. There may be restrictions for use that will limit the effectiveness of the system. Vacating the band would require identifying a new comparable band and equipment modification. Overall operational impact is minimal since only four models have been made so far. However, a change will delay fielding and use by Army infantry units, Air Force security forces, and NASA launch facilities monitoring.

6.2.5.5 Aberdeen Test Center

Without any mitigation, interference from IMT-2000 users operating at the same frequencies would disrupt the acquisition of data in support of the testing of military vehicles and equipment, essentially shutting down the test range. Segmentation will require modification or replacement of the range equipment. Additional frequencies must be made available and selected to eliminate interference with the current frequencies. Unless additional spectrum is allocated and current regulatory protections extended until new equipment is procured and fielded, range operations will be affected adversely.

6.2.5.6 TOSS

If mitigation from IMT-2000 is not used or the system is not replaced, TOSS would be rendered non-operational. Without the feedback from TOSS, range scoring would revert to manual methods. This inability to produce near-instantaneous feedback negatively affects the quality of crew training. Training missions involving multiple bombing runs would not have the benefit of feedback from previous ordnance drops to correct any deficiencies before the next drop. Aircrew proficiency in weapons delivery will be reduced.

6.3 ALTERNATE BANDS

Alternate bands identified in the study plan (2025-2110 MHz, 2200-2290 MHz, 4.4-5.0 GHz and 7-8 GHz) were evaluated to investigate the potential for housing DoD systems that may be displaced through accommodation of IMT-2000. Review indicates these bands could not accommodate the introduction of the additional non-space systems without operational degradation to and from critical systems such as the Cooperative Engagement Capability, the Defense Satellite Communication System, DoD satellite downlinks, and numerous fixed and mobile operations. The 2025-2110 MHz band may be feasible for the introduction of the DoD satellite operations functions but there are specific regulatory issues that must be addressed. Although other bands were not evaluated in this report, the availability of sufficient comparable spectrum is unlikely in light of the ever-growing demand and competition for spectrum access. Finally, availability of comparable spectrum must be certified in accordance with NDAA 2000 prior to any reallocation decision involving some or all of the 1755-1850 MHz band.

In assessing the feasibility of sharing or segmentation of the designated band, or migration out of the band, this report addressed only existing and planned DoD systems. Given the growing demand for spectrum to support information-intensive operations, it is highly likely that new DoD requirements for this band and other DoD bands will arise. Thus the full impact to DoD of surrendering all or a portion of the band may be greater than the assessment provided in this report.

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